United States Environmental Protection Agency **Office of Research and Development**

National Exposure Research Laboratory
Research Abstract
Government Performance Results Act Goal: Clean, Safe Water

Significant Research Findings:

Workshop on Statistical Analysis of Monitoring Beach Water Data for Local Communities

Scientific Problem and Policy Issues

Current EPA recommendations for monitoring bathing beach water quality are based on guidelines developed in 1968 by the Federal Water Pollution Control Administration. The guidelines specify that the geometric mean density of a fecal indicator organism, from five water samples collected over a thirty day period, be used to establish the acceptability of the water for public use. Data obtained using the current sampling protocol is of limited use, since it provides only a gross measure, both spatially and temporally, of water quality and associated health risks from its recreational use. The purpose of this research was to develop a scientifically defensible monitoring protocol for bathing beach waters, which accounts for spatial and temporal variability, has national application, and can be translated into risk management and/or communication strategies to inform the public about risks associated with swimming activities.

Research Approach

Utilizing the recreational waters monitoring protocol developed by ORD, intensive sampling studies were conducted in the summer of 2000 at five of EPA's Environmental Monitoring for Public Access and Community Tracking (EMPACT) program city sites to characterize the sampling variability encountered at marine, freshwater, estuarine, and riverine bathing beaches. The design for the study was developed through a data quality objectives workshop attended by microbiologists and statisticians, and was based on data collected from a pilot project during the previous bathing season. At each beach, water samples were collected from a depth of 0.3 m below the surface at each of nine locations in the bathing area, fixed in terms of transects extending from the shoreline and water depth, twice daily, at 9:00 a.m. and 2:00 p.m., over the period 1 July - 31 August, 2000. Additional samples were collected on selected days as replicates of the basic samples, at different depths below the surface, or at different hours throughout the day (hourly) to supplement the basic sampling scheme. Standard plate assays were used to determine the number of the respective indicator bacteria per 100 mL in each sample. *E. coli*

and enterococci indicators were measured. Ancillary data were collected at each sampling visit, including weather data (air temperature, wind direction, etc.), and recreational/wildlife data (swimmers in the water, people on the beach, boats, animals, etc.). A preliminary analysis of the results from this study was performed and encompassed two distinct objectives — characterization of sampling precision associated with various sampling plans and modeling for forecasting indicator densities. Results from the study and these analyses were discussed at the Workshop on Statistical Analysis of Monitoring Data for Local Communities, which was held at the U.S. EPA in Cincinnati, OH, and attended by four statisticians of national and international prominence in the field of water monitoring, in addition to one EPA statistician.

Results and Implications

This Annual Performance Measure (APM 76) supports FY01 Annual Performance Goal 012 which states: "Develop decision support statistical tools for the watershed guidance in the watershed restoration strategy." Significant findings were as follows:

1.) The effects of water depth, time-of-day, and the various weather and environmental data and their interactions on log density of the respective indicator organism were evaluated and found to decrease in terms of log density with increasing water depth and from morning to afternoon, particularly on sunny days. Both factors have important implications for design of a monitoring program. A dependency on water depth suggests that the bathing area be subdivided into different zones, or "strata", for purposes of sampling, and a weighted average of these strata be utilized in developing the water quality index; allocating the samples by stratum enables the collection of fewer samples overall because of the relative homogeneity within each stratum as compared to variance among strata. The observation that afternoon results are likely to be lower reinforces the practice of sampling in the morning. While indicator levels are likely to be lower in the afternoon, this does not necessarily imply that contamination, or any associated adverse health effects, are also lower. The decline in indicators may be largely due to their die-off from ultraviolet radiation, as supported by the relationship to sunlight, which may or may not affect each of the variety of pathogenic organisms that might co-exist with these indicators.

2.) Other effects, notably those for wind, tides, and rainfall, were observed in some instances, and are compatible with point sources of pollution, such as combined sewer outlets and waste discharge channels, known to exist near two of these beaches; in general,

	however, such effects would merit individual study at any beach contemplating a monitoring program. 3.) This research has demonstrated that a fairly modest number of samples, on the order of ten to fifteen samples from different locations in the water, are adequate to insure that contamination levels that are in excess of 150% of established guidelines will be detected 95% of the time. Implications for this research are improved sampling designs for monitoring recreational water quality and improved communication of recreational water quality to the public.
Research Collaboration and Publications	The EMPACT Beaches Analysis Workshop was a collaborative effort between scientists and statisticians from the EPA's National Exposure Research Laboratory, the EPA's Office of Water, the EPA's EMPACT program, and statisticians from outside the EPA and preeminent in the field of environmetrics. Technical results of this effort were presented at the annual conference of The International Environmetrics Society in an invited session in August 2001, to be published in the journal *Environmetrics*. A users' conference, sponsored jointly by the Office of Water and the Office of Research and Development, and open to stakeholders in recreational water quality assessment, is planned for October, 2001. At least five additional peer-reviewed publications, incorporating all phases of the EMPACT Beaches research project, including this workshop, are anticipated.
Future Research	The EPA Action Plan for Beaches and Recreational Waters, published in 1999 (EPA/600/R-98/079), formulates program, policy, and research needs for assessing, monitoring, and communicating "health risks associated with potentially pathogen-contaminated rivers, lakes, and ocean beaches." The outcome from the EMPACT Beaches Analysis Workshop, and the forthcoming users' conference, represents the cumulation of the "Modeling and Monitoring Research" activities. Additional research is ongoing or planned to refine water quality indicators, including the use of rapid methods and new or modified indicators, characterization of human exposure through ingestion and other swimmer behavior patterns, and model human health effects predicted by other indicators through epidemiological studies.

Contacts for Additional Information

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